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Influence of the Carbohydrates on Proteid Catabolism, with Special Reference to Diabetes.

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INFLUENCE OF THE CARBOHYDRATES ON PROTEID CATABOLISM,

WITH SPECIAL REFERENCE TO DIABETES.

*AN ABSTRACT.**

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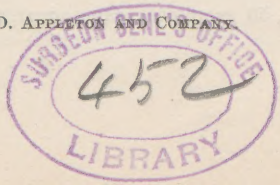
Professors Pettenkofer and Voit, after investigations made some twenty-five years ago, showed that the ordinary mixed diet fully capable of sustaining a strong working man weighing one hundred and fifty-six pounds (seventy-one kilogrammes) was incapable of properly nourishing a person suffering from diabetes who weighed but one hundred and nineteen pounds (fifty-four kilogrammes). The latter continually lost flesh and fat, and consumed less oxygen and exhaled less carbonic acid than the normal man.

In the light of more recent physiological research, Professor Voit, in his book, *Die Physiologie des allgemeinen*

* Ueber den Einfluss der Kohlenhydraten auf dem Eiweisserfall. Von Graham Lusk. (Aus dem physiologischen Institut zu München.) Zeitschrift für Biologie, vol. xxvii, p. 459.



Stoffwechsels und der Ernährung, asks if these changes can not be traced to the non-decomposition of the carbohydrates and their emission in the urine. Professor Voit considered it important to prove whether the wasting away of the flesh and fat in diabetes was alone dependent upon the non-burning of the carbohydrates, or whether, as in fever or phosphorus poisoning, it depended upon a radical change in the cells and in the tissues. If this wasting away be due to the non-burning of the carbohydrates, then a normal person and a diabetic patient of similar bodily construction fed upon albuminoids and fat without carbohydrates should require exactly the same quantity of these two foods. And, further, a person in normal health, on leaving out the carbohydrates from his usual mixed diet, should show a wasting away of flesh and fat similar to that exhibited by the diabetic patient.

Experiments to prove the truth of this latter statement were made by the writer upon himself. His weight at the time was one hundred and thirty-four pounds (sixty-one kilogrammes). The daily quantity of nitrogen in the urine by his usual diet (taking the average of four days) was 14·76 grammes. Adding 2·3 grammes for nitrogen in the fæces, we have an average daily excretion of 17·06 grammes of nitrogen, which is equivalent to the destruction of 107 grammes of dried albumin.

Experiment I.—The procedure consisted in taking for three days the same diet of albuminoids, fat, and carbohydrates, and determining the amount of nitrogen excreted in the urine and fæces, and then taking for the following three days the same quantity of albuminoids and fat without the carbohydrates, and determining the nitrogen excreted under these altered circumstances. The food for the first three days consisted of lean meat, 300 grammes; zwieback, 500 grammes; milk, 200 c. c.; butter, 50 grammes; cane sugar, 21·4 grammes; meat extract,

2 grammes; coffee made from 28·4 grammes grounds; and wine, 500 c. c. This food contained—

Nitrogen..... 20·549 grammes = albumin, 128·44 grammes.
Fat..... 58·54 "
Carbohydrates 357·37 "

When, after the first three days, the carbohydrates (zwieback and cane sugar) were left out of the food, 74·7 grammes of a bread made from gluten was eaten daily in order to exactly replace the amount of nitrogen contained in the zwieback. The food then contained—

Nitrogen..... 20·549 grammes = albumin, 128·44 grammes.
Fat..... 58·54 "
Carbohydrates 10·8 "

The analyses of the excreta gave the following results:

	N in food.	N in urine.	N in fæces.	Total.	Difference.
With carbohydrates:					
For the three days.....	61·647	55·466	4·045	59·511	+2·136
Average per day..... ..	20·549	18·489	1·348	19·837	+0·712
Without carbohydrates:					
For the three days.....	61·647	74·827	2·965	77·792	−16·145
Average per day.....	20·549	24·942	0·988	25·930	−5·381
Average for 2d and 3d days.	20·549	26·017	0·988	27·005	−6·456

The fæces of the first three days contained 4·438 grammes of fat and 0·382 grammes of carbohydrates. For the last three days there were 5·819 grammes of fat.

After the carbohydrates in the food were set aside, their influence was still appreciable during the day following. Hence, for comparison, the first three days and the last two should be taken. It is apparent that 0·712 grammes of nitrogen (= 4·45 grammes of albumin) was daily gained by the body during the first three days, and 6·456 grammes of nitrogen (= 40·350 grammes of albumin) daily lost by the body during the last two. Hence, when 128 grammes of albumin are taken in the food, the leaving out of 357 grammes of carbohydrates produces an increase in the decomposition of albumin equal to 44·8 grammes.

Experiment II.—Here the food was much the same as in Experiment I, but the albuminoid material less. For two days the food consisted of zwieback, 500 grammes; butter, 50 grammes; cane sugar, 20 grammes; meat extract, 4 grammes; coffee from 28·4 grammes grounds; and wine, 500 c. c. The food contained—

Nitrogen..... 9·230 grammes = albumin, 57·69 grammes.
Fat..... 50·0 "
Carbohydrates 347·8 "

Then for the two following days the carbohydrates were left out, and 76·8 grammes of gluten bread were taken in the stead of the albuminoids in the zwieback, as in Experiment I. This food contained—

Nitrogen..... 9·230 grammes = albumin, 57·69 grammes.
Fat..... 50·0 "
Carbohydrates 2·8 "

The analyses of the excreta during the experiment gave the following results:

	N in food.	N in urine.	N in fæces.	Total.	Difference.
With carbohydrates:					
For two days.....	18·460	24·294	3·276	27·570	−9·110
Average per day.....	9·230	12·147	1·638	13·785	−4·550
Second day.....	9·230	11·444	1·638	13·082	−3·852
Without carbohydrates:					
For two days.....	18·460	29·298	2·316	31·614	−13·154
Average per day.	9·230	14·649	1·158	15·807	−6·577
Second day.....	9·230	16·027	1·158	17 185	−7·955

The fæces of the first two days contained 6·532 grammes of fat and 0·611 gramme of carbohydrates; for the last two days, 4·193 grammes of fat.

It will be observed that the eating of 57·69 grammes of albuminoid material was not sufficient to maintain the nitrogen equilibrium of the body, but that on the second day (when the body was fully under the influence of the diet)

the amount of nitrogen lost from the body was 3·852 grammes, corresponding to the decomposition of 24·074 grammes of albumin. Now, after the setting aside of the carbohydrates (on the second day) there is a loss to the body of 7·955 grammes of nitrogen, equal to a decomposition of 49·719 grammes of albumin. Hence, when 57·67 grammes of albumin are taken in the food, the leaving out of 345 grammes of carbohydrates produces an increase in the decomposition of albumin equal to 25·645 grammes.

From this series of experiments it is clear that the omission of the carbohydrates in the food brings about a marked increase in the proteid decomposition; the burning carbohydrates serve to protect a certain amount of proteid matter. It has been shown by M. Rubner, in Professor Voit's laboratory, that the omission of the carbohydrates always produces a relative increase in the decomposition of the body's fat. In other words, a certain amount of non-nitrogenous matter must always be burned with the nitrogenous, in order to fulfill the conditions necessary for the catabolism in the cells and in the tissues. When the sugars are not burned, fat is attacked. Two hundred and twenty-nine grammes of starch are in this relation the equivalent of 100 grammes of fat. Hence, on leaving out the 357 or 348 grammes of carbohydrates in the above investigations, fat must have been burned in the body to the amount of 156 or 152 grammes.

Pettenkofer and Voit, in their former investigations on the diabetic patient in comparison with the healthy individual, have shown the following results when an ordinary mixed diet was taken. The food in each case was the same:

	Albumin.	Fat.	Carbohydrates.
Diabetic patient:			
In the food	137	117	352
Destroyed	188	192	464 sugar in urine.
Change in the body	−51	−84	....
Healthy workman:			
In the food	137	117	352
Destroyed	137	72	352
Change in the body	....	+29	....
Weak but healthy man:			
In the food	137	117	352
Destroyed	137	....	352
Change on the body	....	+118	....

The above-mentioned loss of fifty-one grammes of albumin by the diabetic patient is easily explained by the large excretion of sugar in the urine. For, in my experiments, when the carbohydrates were discontinued, there was a loss from the body of forty-five grammes of albuminoid matter on a diet of one hundred and twenty-eight grammes, and a loss of twenty-six grammes on a diet of fifty-eight grammes. It seems, therefore, in the highest degree probable that the non-burning of the carbohydrates is the cause of the great loss of flesh in diabetes.

The statement made by Pettenkofer and Voit that the diabetic patient consumes less oxygen and exhales less carbonic acid than the normal man has been found to be an error, arising from the fact that the persons compared were of different conditions bodily. When, however, the patient and healthy person are equal in weight and other bodily attributes, the amount of inhaled oxygen is the same, and what is used in health to burn the sugars is, in the case of diabetes, used in the destruction of fat. That the amount of inhaled oxygen and exhaled carbonic acid are the same is further shown by the fact that the heat units produced

to a square metre of surface on both patient and healthy person are equal under similar conditions of diet.

Conclusion.—Those wishing further details and proofs are referred to the original article, but it is clear from the foregoing that all the constitutional changes in diabetes can be attributed to the non-destruction of the carbohydrates. The diabetic patient loses flesh because the albumin-protecting property of the burning carbohydrates is eliminated, and loses fat because an amount of fat is burned equivalent to the sugar burned in the healthy person, and he inhales the same amount of oxygen and exhales the same amount of carbonic acid as the normal man under similar conditions.

It is my wish to gratefully express my obligations to Professor Voit for his every help and suggestion.